GENERAL SCIENCE QUARTERLY

... CONTENTS ...

Published four times a year: in November, January, March and May
By W. G. WHITMAN, SALEM, MASS.

Entered as second class matter Nov. 6, 1916, at Salem, Mass., under the Act of March 3, 1879

$1.50 a year
40c a copy

NOVEMBER, 1927

VOLUME 12
NUMBER 1

General Science Quarterly

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Vol. XII NOVEMBER, 1927 No. 1

The Science Demonstration in the Junior-Senior High School

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Part II-A.

The Organization of the Demonstration.

One of the most important factors in a successful science demonstration is its careful organization. Opportunities are presented in the organization to develop certain abilities in pupils which are given in no other part of a science curriculum. The infinitude of detail in the preparation of the demonstration places a premium on efficient organization, and failure in this point is very liable to mean failure in the entire undertaking.

The plan of organization to be used had best come from the teacher, or committee of teachers, and should be carefully worked out in every detail before its presentation to the various classes. The teachers should see in the planning of this organization every office as holding potential possibilities for the development of some individual. A boy who is weak in leadership ability may be wisely placed at the head of the demonstration as supervisor. A girl who has little interest in science may find herself by assuming some responsibility in the organization of the exhibit. Make each office fill its educational role to the limit of its possibilities.

The general plan of organization should be such as to enable quick and careful checking of the progress of each individual, group, or class. It should relieve the teacher of all detail and should be of such a nature that it is more or less self-operative.

First, each of the science classes is organized. This organization consists of an elected general class chairman and two assistants. It is the duty of these officers to become members of the science exhibit staff and to assume certain responsibili-

ties in regard to checking various phases of the work and other minor duties, many of which arise during the progress of the preparation.

Fig. 7. The demonstration in the hallway—1927.

The above-named class officers, together with a group of specially appointed officers and the teachers, make up the general staff. The executive committee is filled by appointment from the teacher or a committee of teachers. These should include:

1. A general chairman or supervisor, whose duty it is to have general charge of supervising the demonstration throughout. He secures careful, systematic check-ups of the progress of each individual demonstration through the class committees. He supervises the planning of various demonstrations. He refers all problems presented to him to the proper committee or individual. He presides at staff meetings.

2. An electrical engineer. This officer should be a pupil, usually a boy in higher science, well acquainted with the fundamental principles of electricity and also with the electrical circuits of the laboratory and building. It is his function to solve the problems arising in regard to current distribution for demonstration and lighting. Any demonstrator needing a certain voltage or type of current presents his problem and the assigned location of his table to the engineer, who studies the problem and makes the necessary adjustments. This is a very responsible position and perhaps may need more than one person assigned to it.

3. A mechanical engineer. This office is similar in functioning to that of the electrical engineer. The problems of

gas distribution for heating purposes and of mechanical set-ups are referred to him for solution. A pupil familiar with laboratory set-ups and skillful with tools should be selected for this office.

4. A material and equipment engineer. This is a most important office, and may very well be placed in the hands of a committee. Responsibility for all department equipment used in the demonstration is placed on this officer. He checks out every piece and keeps a record of its condition when taken and when returned. It is his duty to see that sufficient ring-stands, clamps, test-tubes, etc., are on hand in good condition for the demonstration, and to see that they are returned to their proper places clean and in good order when it is over. This officer makes plans for the proper amount of space for each demonstrator, and sees to the providing of tables and their covering for protection from mars, etc.

It is necessary to have several meetings of the staff before the preparation is formally begun, and to attempt to anticipate all problems and difficulties before they arise. Such general problems as the following may well be discussed:

1. When will the demonstration be given?
2. How long a time will it cover?
3. How shall we handle the visitors?
4. The appointment of general committees.
5. How each class may function in making the demonstration a success.

The staff will find it necessary to appoint several general committees from the science enrollment at large. These can well be headed by one of the assistant class supervisors. Several of these committees are suggested below. The types and duties of these committees will vary with each school.

1. A committee on the arrangement of the demonstration.
2. A committee on artistic effects.
3. A committee on clean-up after the demonstration.
4. A committee for publicity.
5. A committee on programs.

Each class is allowed to select the unit or units of study in their particular course which they would like to use for demonstration. Since, however, one of the objectives is to provide activities best suited to the individual, it becomes the teacher's duty to divide the unit selected into its parts and assign to each pupil the part which in his judgment will pro-

duce the greatest development or stimulation for that pupil. This is one of the most vital points in the planning of the demonstration and should be handled with great care.

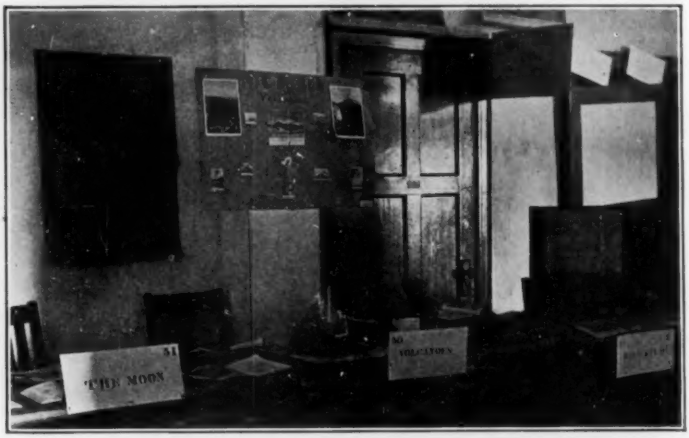

Fig. 8. An interesting part of the 1927 demonstration.

A plan that has been effectively used in the organizing of the individual demonstrations, is that of writing out on a three by five card the name of each demonstration topic, and then of writing the name or names of pupils who are to engage in that activity on the card. A few suggestions may be written here also. These cards are passed on to the general supervisor, who, in turn, divides them up and passes them on to the class supervisors. Here again they are divided, each class officer taking a group of cards and keeping a record of them in a book provided. He passes the cards on to the pupils and is responsible for the checking-up of the progress of the preparation of each demonstration. Reports of these check-ups are made at staff meetings, any difficulties being personally checked up by the general supervisor.

It has been found that a successful demonstration cannot be developed without some encroachment upon class time. This, of course, is justifiable if we regard the demonstration as an educative device and as an instrument of instruction.

The length of time required for the actual preparation will vary, but two weeks of science class time will give an ample

period for the most elaborate undertaking. Usually it can be done in a week or less.

Many phases of science work lend themselves aptly to demonstration. A few which have been used are given below:

1. Charts:
   (a) Diagramatic charts, such as, "The Course of the Blood Through the System."
   (b) Biography charts, such as, "The Life of Galileo."
2. Slides for use with the projection lantern.
3. Films for use with the moving-picture machine.
4. Individual projects in science.
5. Hobbies.
6. Class experiments in science.
7. Lecture topics.
8. Magic demonstrations.
9. Class projects in science.
10. Science club activities.

The radio can be made to play a very distinct part in the science demonstration. During the first science demonstration at John Burroughs School, a local broadcasting station broadcast a special half-hour program for us, which was picked up and rendered through several loud speakers.

A more satisfactory use is made of the radio when a sending station is set up at some remote part of the school building and transmitted by wires to the receiving set. Over this, announcements may be made, victrola selections, and even vocal and instrumental numbers rendered with surprising quality and clearness. A good hookup for such a sending and receiving circuit is reported by M. E. Herriott in the February, 1925, issue of School Science and Mathematics.*

Lighting plays a very important part in the effectiveness of the demonstration and should be given careful attention by a committee. Several pupils have made electric flash signs for their particular part in the demonstration. These have been novel and have attracted considerable attention.

It is wise to have a placard at each demonstration. This should be made on white cardboard about six by twelve inches, and should have the following things on it:

1. The name of the demonstration topic.
2. The grade in which this topic is studied.
3. The serial number assigned by the committee on the general arrangement of the demonstration. Several cards may be seen in the cuts throughout the article.

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* Assembly Programs from Class Work. M. E. Herriott, School Science and Mathematics, February, 1925.

These cards are placed in wooden blocks provided for the purpose, and made to stand upright on the table. They seem to answer the question, "What are you doing?" which is asked by nearly every visitor.

The serial number enables the visitor to quickly refer to the program for information in regard to the demonstration, or it enables him to follow progressively the demonstration from the first exhibit to the last. Experience has taught that these placards are best made by use of brass stencils which may be procured from any hardware supply house. This makes the entire group uniform and much more attractive than individual printing.

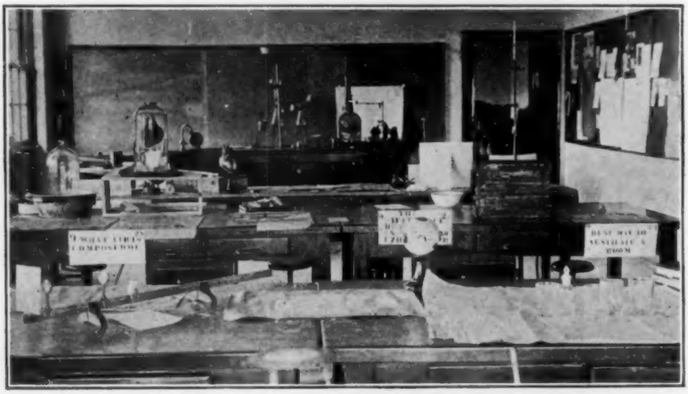


Fig. 9. The demonstration in the General Science Room—1927

Pupil interest may be stimulated by issuing a series of mimeographed bulletins on the exhibit. The sample shown is typical:

Science Exhibit.

BULLETIN I.

April 16th IS THE DAY.

The Science Exhibit of 1926 is well under way and from every angle appears to be developing in a manner to insure its success. The undertaking is a big one and it is only by each one doing his or her part to the very best of their ability that it will measure up to Science Exhibits of the past.

Look upon your project as an opportunity to develop not only a series of topics but an opportunity for you to grow, to get new information, perhaps from several different angles, to take this new material, develop it, organize it, and finally bring about the completed work and really feel the thrill of achievement.

A FEW POINTS TO NOTE.

1. Do not leave your project for the last week. Begin planning and developing it now.

2. Consult the instructors in the department freely and call upon them for suggestions.

3. Another bulletin will come out very soon with a chart of table locations.

4. Your suggestions for decorating will be appreciated.

5. The organization of classes for the exhibit is as follows:

7 X	Supt.	Chas. Depew	9 X	Supt.	Gilbert Pirrung
7 Y	Supt.	Ivan Lee Holt	9 Y	Supt.	Anne Robinson
8 I	Supt.	Proctor Dodson	10	Supt.	K. Boyd
8 II	Supt.	Billy Rench	11 & 12	Supt.	Erna Rice

THE ART COMMITTEE

Clark Smith, Chairman
Austin Smith
Wm. Bascom
Rosalind Corn
Jane Francis
Franz Wippold
Harold McCoy

ELECTRICAL ENGINEER

Cary Jones

EQUIPMENT ENGINEERS

John Douglass
David Kammerer

GAS ENGINEER

Merrick Foster

6. Any problem of an electrical nature should be referred to the engineer in charge of this work.

7. Any problem involving the use or distribution of gas should be referred to the engineer in charge.

8. Any equipment taken out for the demonstration *must be charged* out by the equipment engineers. Please give this your careful attention.

9. The Junior School classes are preparing exhibits on the following general topics:

7th Year.
1. The Story of Science.
2. Miscellaneous Science Projects.

8th Year.
1. The Air We Breathe.
2. The Weather and its Changes.
3. The Food We Eat.

9th Year.
1. Electricity in a Modern City.
2. The Gas Supply of a Modern City.
3. Bacteria, Yeasts, and Molds.

PART II-B.

The Presentation of the Demonstration.

A fine and carefully worked-out organization and preparation may be rendered ineffective by a poorly planned presentation. The presentation is, in the final analysis, the success

or failure of the demonstration, and is no doubt a test of the organization and preparation. The staff should consider the presentation from every possible angle and should attempt to see the entire lay-out in prospect. Some of the problems which experience has shown important are:

1. The amount of table space necessary for the effective presentation of each topic.
2. Ways and means of keeping the crowd moving.

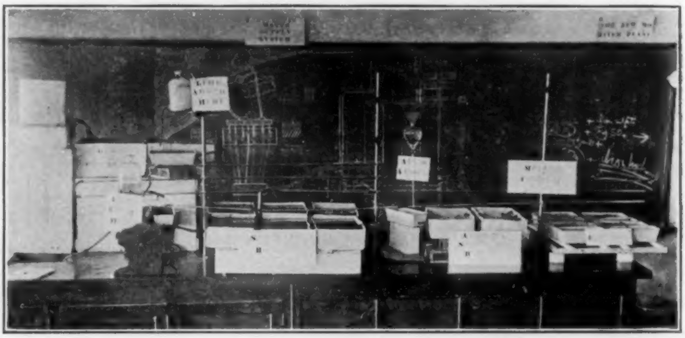


Fig. 10. A working model of the St. Louis Water Purification Plant—1927

3. The progressive arrangement of topics.
4. The securing of tables, etc., with the least interruption of other school activities.
5. The provision of sufficient materials at each demonstration for the entire time.
6. The provision of sufficient time to enable everyone to see the demonstration thoroughly.
7. The problem of pupil fatigue.

The best method to follow in giving the demonstration is still somewhat of an unanswered question with us, even after three years of experience. We have not decided whether it is better to repeat the demonstration periodically each half-hour, or to have it continuous. At the present time the latter method appears the better. This keeps the crowd moving from one demonstration to the next and seems to eliminate congestion at any one table.

The arrangement of the demonstration is a knotty problem which will need very careful consideration. One of the objec-

tives, of course, is to duplicate as nearly as possible actual classroom procedure in the demonstration. This becomes exceedingly difficult under the highly artificial conditions of the exhibit. To render this objective as concrete as possible, we have attempted to place all the topics of each demonstration unit together and, with few exceptions, in a progressive arrangement, starting with the first topic of the unit and concluding with the last. There are, of course, serious difficulties to overcome in carrying out such a plan. One demonstration, for example, may require running water, and it may be next to impossible to provide it unless the entire group is moved.

When the progressive arrangement can be used, however, it is the best. The placards on the tables should be numbered consecutively to show the visitor the progressive idea. A note in regard to it on the program will also insure more effectiveness to the visitor.

The pupil is encouraged to be very natural in the rendering of his topic, and to explain all details of apparatus. He is also encouraged to be as brief as is consistent with clearness. The visitors are encouraged to ask questions of the demonstrators.

The program is an important part of the demonstration and should include information in regard to the exhibit. The programs of the demonstrations of 1925 and 1926 are given below. It will be noted that the 1926 program was much more comprehensive than the one of 1925, containing the detailed list of pupils and topics. This was found to be worth while, as evidenced by the favorable reaction of the visitors.

Exhibition of the Classroom Work in Science of the John Burroughs School.

February, 1925.

The object of the Science Exhibition is to give the patrons of the School an opportunity to see as nearly as possible the type of work which the boys and girls are doing in the laboratory. The work which you see in progress is the type of work which we do each day.

To make the exhibition as interesting as possible, the work of each grade except the 7th is organized about a central topic, and the demonstrations as far as possible are arranged in a progressive development of the topic. The following outline will help you enjoy the visit:

A. On the second floor corridor will be found the exhibit of the 10th year Biology class. The central theme of this demonstration is The World Food Problem.

a. Sources of the World Food Supply.
b. Roots and Their Relation to the World Food Problem.
c. Stems and Their Relation to the World Food Problem.
d. Leaves and Their Relation to the World Food Problem.
e. The Uses of Foods to the Body.
f. The Various Types of Foods.
g. The Amount and Type of Food We Need.
h. Alcohol and Tobacco, Their Effect on the Body.

There are numerous charts and graphs which will interest you.

B. In the rear of the Science room will be found the exhibit of the seventh year. Many interesting biographies, stories, charts and devices will be found.

On the back tables will be found the demonstrations of the seventh year. Here the boys and girls may be seen carrying on their little investigations, attempting to solve the problems and at the same time get a peep into the many interesting fields of science.

C. On the middle tables will be found the demonstrations of the 9th year group centering about the topic of Water and the Water Supply. At present they are making a detailed study of the St. Louis Water Supply System and many graphs, maps and charts have been made by the pupils. These will be found on the east wall of the Science room. They are worth inspection.

CAN YOU EXPLAIN WHY THE FLASK AT THE SINK DOESN'T BECOME EMPTY?

D. At the front of the room may be found the exhibit and demonstration of the 8th year group, centering about the topic Air and Weather. The exhibit contains many home-made weather instruments, charts, graphs and biographies. The demonstration contains a miniature weather bureau where the children make daily readings and forecasts.

E. The patrons are asked to follow the line through the demonstration and not to congest the aisles. As far as possible keep in single or double file while passing the table demonstrations. Pupils are stationed at each exhibit to explain charts, graphs, diagrams, maps, etc.

Science Demonstration,

John Burroughs School, April 16, 1926.

PROGRAM.

The science demonstration of the John Burroughs School has become an annual event and is looked forward to with great eagerness by the children in the various science classes. It is with a sense of achievement that they have prepared this year's exhibit for the patrons and friends of the school, for its scope has been greatly broadened. They have undertaken to show you the varied things that go on in the class-room and trust that you will enjoy it as much as they have its preparation. The demonstrations will be continuous, and if you ask questions they will be welcomed by the children.

GENERAL PLAN OF THE EXHIBIT.

The exhibit covers the floor space of the 2nd corridor, the General Science Room, and the Physics Laboratory. The demonstrations are

in general grouped by grades and then by topics under the grade grouping. In most cases the topic groupings form a developed series and should be observed in proper order to be fully appreciated.

To aid in this, each demonstration is numbered and labeled. The number in the upper left hand corner of the card is the grade to which the child belongs, and the number in the upper right hand corner, the demonstration number. Start at number one in the front of the Physics Laboratory and follow through.

A list of the demonstrations, their numbers, and the grade of pupils responsible for them, follows:

THE ELECTRICAL SUPPLY OF A MODERN CITY.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
1. Electricity from Steam and Water Power	9	5. Heat from Electricity	9
2. The Electrical Transformer	9	6. Work from Electricity	9
3. A Simple Power Plant	9	7. The Two Kinds of Electric Current	9
4. Light from Electricity	9	8. A Miniature Country Home	9

THE GAS SUPPLY OF A MODERN CITY.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
9. How Water Gas is Made	9	13. How a Gas Stove Works	9
10. How Coal Gas is Made	9	14. How to Save Gas in Cooking	9
11. How Gas is Stored	9	15. Coal Tar and its Importance	9
12. How Gas is Measured	9		

WEATHER AND ITS CHANGES.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
16. The History of the Thermometer	8	26. Measurement of Relative Humidity	8
17. The Various Thermometer Scales	8	27. Weather Forecasting	8
18. Various Methods of Temperature Measurement	8	28. Why It Rains	8
19. The Mercury Barometer	8	29. Evaporation and How it Goes on	8
20. The Aneroid Barometer	8	30. Air Exerts Pressure	8
21. How Heat Affects Air	8	31. Air Presses Heavily	8
22. Warm Air Lighter than Cold Air	8	32. Making a Thermometer	8
23. Why Winds Blow	8	33. How a Thermometer Works	8
24. A Study of Condensation	8	33a. A Study of Ventilation	8
25. Weather Lore	8	34. How Storms Travel	8
		35. Weather Maps	8

THE STORY OF SCIENCE.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
36. Davy and the Safety Lamp	7	40. Early Methods of Telling Time	7
37. Bunsen and the Bunsen Burner	7	41. Galileo, the Father of Modern Science	7
38. Faraday and his Discoveries	7	42. The Clock of the Geologist	7
39. How Man Harnesses Nature	7		

PROJECTS BY THE SEVENTH GRADE.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
43. Home-made Telegraph Sets	7	53. An Electric Buzzer	7
44a. A Wireless Sending Set	7	Copper Plating	
45. Making Ink	7	54. Making Coal Tar and Coke	7
46. Making Flasks from Electric Light Bulbs	7	Making an Acid from Wood	
47. Making Paints	7	55. The Electro Magnet	7
48. Removing Spots and Stains	7	56. Making Soap	7
49. Some Interesting Insects	7	57. My Home Laboratory	7
50. Making Carbon Dioxide	7	58. My Hobby, "The Aquarium"	7
51. Making Hydrogen	7	59. My Home Laboratory	7
52. The Tools of the Scientist	7	60. Chemcraft Set	7
		61. Wireless Receiving Set	7
		62. Things We Have Made	7

FOODS.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
63. Extracting Starch from a Potato	8	65. How Starch is Changed to Sugar	8
64. How Starch is Made	10	66. What Milk is Composed of	8

OUR WORK WITH BIRDS.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
67. Bird Banding	10	68. General Bird Program	9

BIOLOGY.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
69. The Value of Trees	10	72. The Digestive System	10
70. An Ant Colony	10	73. The Nervous System	10
71. Osmosis	10		

THE WORLD OF LITTLE THINGS.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
74. What's in a Yeast Cake?	9	80. The Work of Bacteria	9
75. Fermentation	9	81 Bacteria Gardens and 82. What They Show	9
76. Yeast under Different Conditions	9	83. Circulation in Animals	10
77. Yeast in Bread Making	9	84. Circulation in Plants	10
78. Molds and Their Work	9	85. Projection of Microscopic Forms	10
79. Bacteria and What They Are	9		

PHYSICS.

Demonstrations	*Grade*	*Demonstrations*	*Grade*
86. Simple Machines Outside the Home	12	92. Steam Power	11
87. Artificial Refrigeration	12	93. Interesting Experiments with Light	11
88. Liquids in Everyday Life	12	94. Cells and Batteries	12
89. Heat in the Home	12	95. Simple Machines in the Home	12
90. Gas and Oil Engines	10	96. Molecular Phenomena	11
91. Some Interesting Things About Water	12	97. Radiant Energy	11

From every point of view our experiences with the science demonstration have been most valuable. As a means of motivating science activities is has few equals. The pupils enter into the preparation and presentation of the demonstration with an interest and zeal which cannot fail to yield valuable outcomes, intangible and immeasurable as they may be. The mere contact with the various demonstrations creates interest and attitudes in the younger pupils for the science of the later years. In the case of several pupils, the seeing of the demonstration of some out-of-school science activity has created interests in them which have been fruitful.

From the patrons of the school come most favorable reactions. They are enabled to see and get more concrete ideas of the type of materials with which the children are dealing.

It is with a great deal of satisfaction that we pass this on and endorse it as a worthwhile educational device.

Scales for Rating Pupils' Answers to Nine Types of Thought Questions in General Science

For use in Junior and Senior High Schools

CHARLES W. ODELL, Director of Education Research
University of Illinois, Urbana, Illinois

THE CONSTRUCTION AND USE OF THE SCALES

The construction and derivation of the scales. The scales[1] which follow are composed of answers written by pupils from high schools in the State of Illinois and rated by a number of experienced teachers, about half of whom were also graduate students at the University of Illinois. The first step in construction was the determination of the types of questions which should be dealt with. A study was made of the twenty types of thought questions listed by Monroe and Carter[2] to determine those most suitable for the purpose, that is, those to which the answers appeared most readily to lend themselves to rating by the use of scales. As a result the nine types included were selected. Five or six questions of each type were prepared, most of these being selected from lists of examination questions actually used by teachers, and the whole number arranged in five

1 In addition to the scales in General Science, similar sets have been prepared in three other high-school subjects. The four subjects, civics, general science, American history, and English literature, were chosen as being representative of those in which thought questions are, or should be, prominent, and also as being among those carried by large numbers of pupils.

2 Monroe, Walter S., and Carter, Ralph E., "The use of different types of thought questions in secondary schools and their relative difficulty for students." University of Illinois Bulletin, Vol. 20, No. 34, Bureau of Educational Research Bulletin No. 14. Urbana: University of Illinois, 1923, 26 p.

lists. One list was sent to each of several hundred high school teachers with the request that the questions be written on by pupils and the answers sent in. After several thousand papers had been received, they were given a preliminary rating by an experienced teacher and the results tabulated. The one question of each type which had the best distribution of answers from the standpoint of having a fairly large number at each of the degrees of merit used, was determined, and one hundred pupil answers to each of these questions selected, so that the number at each degree of merit was as nearly the same as possible. In some cases there was a dearth of very good answers and a few prepared by teachers were included in the group of one hundred. Each group of one hundred was then rated by several persons, all of whom were experienced teachers, and most of whom had had graduate training. On the basis of these ratings the one answer for each value from zero to 10, inclusive, upon which there was the highest agreement was chosen, and each set of eleven arranged in ascending order of merit to form a scale. Finally, criticisms of the specimens were prepared, showing why each was better than the poorer specimens and worse than the better ones on the same scale. These criticisms also represent the composite judgment of several persons.

The arrangement of the scales. It will be seen that the scales are arranged in this article in the alphabetical order of the names of the types of thought questions to which they apply. Following the name of each type the question used is stated. The answer rated as having a value of zero is then given, followed by the criticism of that answer, then the answer given a value of 1 and the criticism of it, and so on, up to the answer valued at 10 and its criticism. In each case, a whole scale is contained upon a single double page, so that all of it can be in view at once. Thus on pages 2 and 3 is the complete scale for analysis, on 4 and 5 for comparison, and so on. The attempt has been made in the criticisms to point out just as exactly and definitely as possible why each specimen is better than the one just inferior to it and not as good as the one just superior. In some cases it happens that certain features of an answer are better than the corresponding features of another answer which received a higher rating, but in the criticisms such cases are comparatively neglected and the better qualities of the second answer pointed out.

The use of the scales. The method of using these scales is similar to that of employing handwriting, composition, and other similar scales now in more or less common use. In the first place, a teacher should study the scale or scales which are to be used, not only to get them in mind in a general way, but also to understand the criticisms and see why each specimen is rated as it is. After he has become reasonably familiar with both the specimens included and the criticisms, he is ready to begin the actual rating of pupils' answers. This rating will be more easily done if the pupils are asked to write upon the same questions used in the actual construction of the scales but it is only occasionally that this is practicable. For a teacher who has had little or no experience in the use of scales it will probably be well, if possible, to use the same questions for a few times at first before attempting to rate answers to other questions. In either case, a pupil's answer should be compared with the specimens on the proper scale until the one is found which it most nearly resembles in merit, and then given the rating of that scale specimen.

The best procedure in rating is to begin by comparing the answer to be rated with the specimen having a value of zero, then with value 1, value 2, and so on up, until one has proceeded far enough,

or, in other words, until the specimen on the scale which he judges to be of the same value as the answer being rated is reached. Although by careful comparison fairly reliable ratings can be determined by this method alone, it is better not to trust to the one rating, but after it has been found for a single answer to start in at the other end of the scale and compare the paper being rated with value 10, value 9, and so on, in descending order, until the proper value is reached. If the same value is arrived at in the ascending and descending order, it should be recorded as the value of the answer being rated. If not, the rater should make further comparisons of the answer with the scale specimens and criticisms until he is satisfied what rating it should receive.

It is recommended that in using these scales, at least until one becomes decidedly familiar with them and relatively expert in their use, two or more scorings be made of the answers rated. A teacher should either rate a set of answers and record the results so that they will not be visible, and then after some time has elapsed rate them again, or two teachers should rate the same set of answers independently. In either case, the results should be compared and discrepancies studied until the reasons are determined and agreement arrived at. Most teachers can profit by a considerable amount of practice of this sort, and will find that the reliability of their rating is decidedly increased by so doing.

The persons who rated the answers from which the scales were constructed, were instructed that English was to be taken into account only as it affected the sense, that is to say, no conscious deductions were to be made for poor handwriting, incorrect capitalization, punctuation, spelling, sentence structure, paragraphing, and so forth, except in so far as certain of these faults obscured or changed the meaning. This practice should be followed in using these scales, and no comparisons made on the basis of the number of grammatical or rhetorical errors. In other words, the scales are to be used for the purpose of determining the merit of pupils' answers with regard to the amount of knowledge and ability displayed in the field of learning to which they apply, not in grammar and rhetoric It has seemed best, however, to reproduce the pupils' answers with all of the original errors present. In printing, of course, quality of handwriting is not shown.

It is sometimes recommended that ratings half-way between the values on the scale be given. For example, if an answer seems better than the specimen at value 6 but worse than that at value 7, it is given a rating of 6.5. The writer does not recommend this method of rating, however, chiefly for the reason that the units in the scale are relatively crude and do not warrant further refinement. Also, a scale running from zero to 10, inclusive, discriminates finely enough for answers of the lengths used in the scales and commonly given by high school pupils when asked to reply to similar questions. The attempt to rate more finely and give ratings half-way between those on the scales would usually result in a false appearance of exactness which the ratings so given would not be reliable enough to justify.

The practice of rating each pupil answer twice, by the same or different teachers, and indeed the formal use of scales at all, requires a considerable amount of time. After a teacher has familiarized herself with the scales and made considerable use of them, she should have fixed in her mind much more definite standards of marking than before, and therefore be able to mark much more accurately, even though the scales are not actually before her. In fact, it is probable that, on the whole, the greatest value of scales such as these is to be found in their effect in standardizing and validating teachers' conceptions of what constitutes merit in pupils' answers, rather than in the direct use of the scales.

Norms. Although answers from many thousands of pupils were collected and rated, sufficient information is not available to establish reliable norms of achievement or bases of changing scale scores into school marks. For senior high school pupils it will probably be roughly satisfactory to multiply the scale scores by ten to secure percent marks, but for those in junior high schools this procedure will undoubtedly be too severe.

TYPE I.—ANALYSIS[3]

What steps compose the process of pasteurizing milk?

VALUE 0

Pupil Answer. The steps composed in pasteurizing milk are (1) First the milk is placed in bottles that have been boiled with very hot water. (2) Then they have lids put over them. (3) Then they are sold.

Criticism. No knowledge of the process of pasteurization is shown. The sterilizing of the bottles is confused with the pasteurization of milk.

VALUE 1

Pupil Answer. The pasteurization of milk is: The milk is cooled after taken from the cow and then it is placed into a large tank and it is heated to 212° F and it does not injur the milk. This just bring the milk to boiling point.

Criticism. This answer shows very little knowledge of the subject. It is stated that milk must be heated, but the temperature given, 212° F, is too high. No mention is made of the use of hot water in the process.

VALUE 2

Pupil Answer. The way of pasteurizing milk is taking water and letting it come to a boil. Then taking the milk and setting it down in the hot water, but not letting it come to a boil. If you let the milk come to a boil it will take all of the minerals out of the milk.

Criticism. This discussion definitely states that the milk must not be heated to the boiling point. The reason given as to why milk should not be boiled is false, minerals being confused with vitamines. The following points are omitted: degree of heat, cooling, and bottling processes.

VALUE 3

Pupil Answer. The milk is brought from dairy farms and it is raw. Then they heat the milk to a degree of 180°, and

3 The author will be very glad to receive criticisms or suggestions regarding these scales from those who read them.

let it cool. They then put it in bottles ready to be shipped away for selling.

Criticism. This paper speaks of heating milk to 180°, then cooling and bottling it. In stating the temperature no reference is given to the scale but regardless of whether Centigrade or Fahrenheit is used, 180° is too high. No mention is made that the purpose of the heating is to destroy germs nor of putting the milk into sterilized bottles.

VALUE 4

Pupil Answer. After the milk is taken from the cow the milk is cooled. then it is put into a large can where it is heated to 147° F. This kill all germs that the milk may contain. After this the put in into steralized bottles so that no germ may enter.

Criticism. The temperature to which the milk is heated (147° F.) is more accurately stated than in Number 3. The reason given for heating milk is that it kills germs which may be in the milk. Mention is made of putting the milk into sterilized bottles after pasteurization. Neither the length of time of heating, nor an explanation of how the milk is heated and then cooled, is included in this discussion.

VALUE 5

Pupil Answer. In one process of pasteurization the milk passes through pipes surrounded by water heated to between 60° and about 180° for 20 minutes or more and is then cooled by passing through pipes surrounded by cold water.

Criticism. This answer explains how milk is first heated by passing through pipes surrounded by hot water, and then cooled by passing through pipes containing cold water. Twenty minutes is given as the length of time of heating. Pasteur is not given credit for discovering the process. No mention is made that pasteurization kills germs without killing helpful substances or changing taste. The temperature to which the milk is heated is given as between 60° and about 180°, which is very indefinite, especially as no mention is made of whether this refers to the Centigrade or the Fahrenheit scale.

VALUE 6

Pupil Answer. Pasteurizing milk was first done by Prof. Pasteur a French scientist. It is worked out in this way. The milk is heated to about 150° foor twenty minutes thus killing the germs, but not killing helpful substances or changing the taste.

Criticism. Pasteur is given credit for discovering the process. This paper states that pasteurizing kills the germs, but does not destroy the helpful substances or change the taste. The discussion gives more emphasis to the purpose of pasteurization than to an explanation of the method of pasteurization. The first sentence is not a part of the discussion of the process and the description of the process is very incomplete.

VALUE 7

Pupil Answer. The Process of pasteurizing milk is by

A. first they separate the milk or cleanse it then it runs into a large churn like
B. which has steam heated pipes which rotates this water in these pipes are heated to 142° and held there for thirty minutes then it is ready to run over
C. cooling coils which cools this milk until it is real cool.
D. Then it is put into the bottles where it is bottled and then it is taken to the customers.

Criticism. The explanation of the steps in the process of pasteurization is more complete than in Number 6, but less definite in describing the details of the process than in Number 8.

VALUE 8

Pupil Answer. The steps used in the process of pasteurizing milk are: First the milk is poured into a large bowl and from this bowl it runs into (2) Purifyers. From the purifyer into the (3) cooler and from the cooler into where they Bottle it from there into the (4) store room (5) Some have clearifiers and some do not. (6) Pasterizur.

After the milk poured into the bowls it is clearified Clearified removes all bad things. To clearify it is to make it more cleaner.

It goes from the clearifier into the pasterizer where is it heated for 30 minutes to a temperature of 140° to 145° degrees Fahrenheit. The milk is put into a larg pot and small pipes goes around and around on the inside of this. In the inside of the pipes their is hot water that keeps the milk at that temperature.

It goes from the pasterizer into the cooling coil where the milk is cooled instantly from 140° to 45° F. Over the coils is a constant flow of cold water which cools it.

It goes from the cooling coils to the machine which bottles it then it is put into the store room where it is keep until it is ready to be sold or used.

Criticism. The temperature to which the milk is cooled after heating (45°) is mentioned. The steps of pasteurization are explained in a fairly complete but rambling manner. This answer does not tell that pasteurizing kills the bacteria without changing the taste. Pasteurization is not defined, as in the first sentence of Number 9.

VALUE 9

Pupil Answer. Pasteurizing milk is a process by which is made possible the keeping of milk longer without it spoiling. There are many steps in the pasteurization of milk.

First—The milk is put through a clarifier which removes all the tiny particles of trash.

Second—It is put into a large tank to be heat. It is heat to about 145° F. it is kept at this temperature for about Twenty of thirty minutes.

Third—After being heat for the necessary time it is allowed to run over cooling coils which quickly cools it so as to kill all the bacteria and not change the taste of the milk.

Fourth—As it runs over the cooling coils and is cooled then it is run in to the bottles by another machine.

Fifth—After this is put in boxes and delivered to people.

Criticism. This discussion brings out that pasteurizing is a process by which it is possible to keep milk longer without spoiling, and that heating the milk to 145° F. and cooling it quickly kills the bacteria, but does not change the taste of the milk. Only one of the two methods of pasteurization is described. The fact that the purpose of pasteurization determines the method is omitted. The varying degrees of efficiency of the different methods are not stated.

VALUE 10

Pupil Answer. The two chief purposes for the pasteurization of milk are to increase its keeping quality and to destroy disease-producing organisms. The purpose for the pasteurization determines the method to be used. In commercial pasteurization where the chief purpose is to improve the keeping quality of the milk, the "flash" or instantaneous method is used. The milk is heated to a high temperature about 160° F. for a few seconds, not more than a minute, and then cooled.

By this method varying decrees of efficiency are obtained, depending upon the bacterial content of the milk, the degree of heat and length of exposure to it, and the temperature to which the milk is cooled. This method is not extensively used now for market milk because the temperature and time of exposure of any particle of milk cannot be accurately controlled, and also because this method cannot be depended on to kill all the disease-producing organisms which may be in the milk.

Where the chief purpose is to kill the disease-producing organisms, the "holding" method is used. The milk is heated to 145° F., held at that temperature for twenty or thirty minutes and cooled. If this is properly done, most of the organisms except spore forms should be killed, and the finished product should contain only a small percentage of the original germ content.

Criticism. This paper explains in a clear-cut, concise manner that the purpose of pasteurization determines the method to be used. The "instantaneous" method, which consists of heating the milk to about 160° F. for a few seconds and then cooling, is used to improve the keeping qualities. The second or "holding" method consists of heating to 145° F. for 20 or 30 minutes, the purpose of this method being to kill disease-producing organisms. The discussion of why milk should be pasteurized is more complete than in Number 9.

TYPE II.—CAUSE OR EFFECT

What causes water to rise in pumps?

VALUE 0

Pupil Answer. Capillary attraction causes water to rise in pumps.

Criticism. This statement is entirely false, and shows no knowledge of the subject.

VALUE 1

Pupil Answer. The water in a lift pump works by means of water pressure the force pump by water and air pressure.

Criticism. This shows little knowledge of the question and states that a lift pump works by means of water pressure, and that a force pump works by means of water and air, statements which are not wholly true. It does not mention valves as aids in causing the water to raise.

VALUE 2

Pupil Answer. Water rises in a pump because when the valve is pulled up it closes and carries the water to the spout and when it is let down it opens and lets the water rush to the top of the valve, thus when the handle is pulled up the water comes from the spout.

Criticism. Valves are spoken of as aids in raising the water. This discussion is more complete than Number 1 and is free from false statements. It does not show that the water rushes into the barrel of the pump to take the place of the air forced out.

VALUE 3

Pupil Answer. Water rising in a pump is caused by, (1) the air is taken out of the barrell (2) the piston is raised (3) the water rushes in to take the place of the air.

Criticism. This answer states that water rushes into the "barrell" of the pump to take the place of the air that has been forced out. No mention is made of how the air is taken out of the "barrell," nor of why the water rushes in to take its place.

VALUE 4

Pupil Answer. Water rises in pumps because when the pump handle is pushed up there is something that pushes down on the inside of the pump. When the handle is pushed down this thing rises. There is a partial vaccum left and the water flows through a valve very swiftly in. When the handle is again raised there is a valve that is forced open and the water comes through this valve then through the spout and out.

Criticism. Definite mention is made of the partial vacuum that is later filled with water and of two valves. This explanation is clearer than Number 3; it tells how a pump works and gives a more complete discussion as to why water raises in a pump. The point is not brought out that air pressure on the surface of the water forces it into the space from which the air has been removed.

VALUE 5

Pupil Answer. At the upstroke of the handle of a water pump, the air is drawn out. The air pressure acting on the surface of the water forces the water into the space from which the air has previously been drawn out. As more air is drawn out the water rises higher in the pump.

Criticism. This answer states that air pressure acting on the surface of the water forces the water into the space from which the air has been removed. It also states what happens on the upstroke and downstroke of the handle. The action of the two valves in a lift pump is not shown, nor is a drawing used to illustrate how a pump works.

VALUE 6

Pupil Answer. When the handle of the pump is pushed down the upper valve is closed and with the aid of the air the lower valve is opened. The Suction of the air against the water forces causes the water to be raised to the top. When it is raised to the top the water has no other way out. The water exits throuth the spout. This lift is worked by the aid of the air.

(A = Upper valve)
(B = Lower valve)
(C = Spout)

The force pump uses very little air. The water in a force pump is forced out.

Criticism. The explanation given here is somewhat better than that given in Number 5, because of the use of a sketch showing the two valves in a lift pump. The force pump is also mentioned. This paper speaks of "aid of the air" without explaining how the air aids. The following statement in this answer is wrong: "The suction of the air against the water causes the water to be raised."

VALUE 7

Pupil Answer. Water rises in a pump because of a small suction and because of the air pressure pressing down on the water beneath the pump, drives the water up the pipe and through the valve, which closes so it can not go back down again.

When it gets through the lower valve which closes the other valve in the piston opens and lets it pass through then at upward stroke the piston ascends and water flows out of the pipe.

Criticism. Number 7 explains how the air pressure causes the water to raise, while Number 6 merely states that air aids. The connection between the strokes of the handle and the raising of the water is not shown. This discussion is less complete in detail than Number 8, as it gives fewer details of the operation of the parts of a pump.

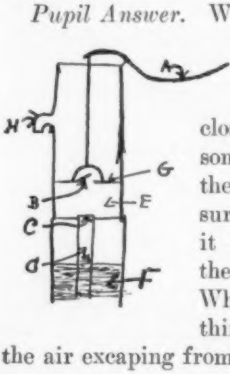
VALUE 8

Pupil Answer. On the first upstroke of the handle, the air below the piston becomes compressed and forces the lower valve closed and the piston valve open and the air escapes. On the down stroke of the handle, the air above and the suction below, closes the piston valve and air is drawn out of the cylinder and the air pressure acting on the surface of the water in the well, forces the water up into suction pipe and forces the lower valve open and then into the cylinder. On the next up stroke of the handle, the water below the piston becomes compressed and closes the lower valve so as not to let the water run back in to the well, and it also forces open the piston valve and the water rises above the piston. On the next downstroke of the handle, the water above the piston forces the piston valve closed, and draws the air out of the cylinder and water is forced up into the cylinder by the pressure acting on the surface of the water in the well. The water above the piston goes out through the spout.

Criticism. This paper shows the connection between the strokes of the handle and the raising of the water. The discussion showing the action of the parts of a pump which aid in causing the water to rise, is somewhat more complete than that given in Number 7. Compared with Number 9, the explanation of the steps in the operation of a pump is not so clear, because the explanation is not accompanied by a diagram. The necessity for priming a pump at times is not stated.

VALUE 9

Pupil Answer. When the handle (A) is up the piston (G) goes down and the valve (B) is opened so that the air may escape. As the handle (A) goes down the valve (B) closes and the valve (C) opens, because the some of the air is pumped out from below the piston (G), and then is some air pressure acting on the surface of the water, so it forces the water up the pipe (d) into the chamber (E) below the piston (G). When the handle goes up again the same thing is done as before, except, instead of the air excaping from the chamber (E) the water does. When



the handle goes down again the water which is already above the piston is forced up and flows out of the spout. (H).

Some times it is necessary to prime a pump to harden its pistons.

The pump's handle must be worked up and down several times to get all the air out.

Criticism. Each step is carefully explained by means of a lettered drawing. The necessity of priming a pump is mentioned. The height to which water may be raised in a perfect vacuum as compared with the height usually attained in practice is not given.

VALUE 10

Pupil Answer. Air pressure cause the water to rise in pumps. The lift pump utilizes air pressure for the purpose of lifting water. When the piston is raised from the bottom of the cylinder there is a partial vaccum created. The pressure on the water in the cistern forces the water up through the valve B. When the piston is lowered the pressure of the water on valve B causes it to close and the water goes up through valve A which is then open. When the piston is raised valve A is closed and the water which has gone past this flows out the spout.

Atmospheric pressure will support a column of water 34 feet long if there is a perfect vaccum. But the usual lift pump will only support a column of water 27 feet high.

Criticism. Although the sentence structure is not good in several instances, the explanation of the steps in raising water by a lift pump is good. Atmospheric pressure is given as the cause of water rising. The maximum theoretical height to which water may be raised by atmopheric pressure and the height usually attained in practice are stated.

(*To be continued*)

The Science of Common Things

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IX. A SPECK OF DUST.*

Good evening, radio science class. During the past week I spent several enjoyable hours reading all the interesting papers you sent in. Yes, I was pleased to receive so many splendid science papers from my radio audience. And I want to present the names of a few girls and boys who deserve honorable mention for excellence in scholarship. They stand at the head of the class:

Florence Chandler
Minerva Abramson
Beulah Meany
Charles Bergin
Marie Lawrence
Katherine Kalsas
Maxime Wright
Lena Leveille
Lucy Healy
Evelyn Hawkes
Matilda McKenna
Francis Cromley
Anna O'Rourke
Mildred McLaughlin
Margaret Fitzgerald
Dorothy Cremin

Of all the schools represented, the Cambridge High and Latin School deserves the first place. Every paper received from there was complete, neat, and carefully written. Now don't forget. Next Monday evening we will have more experiments—new ones—on light. Have the following articles ready:

A short candle one inch long. A few matches. Two drinking glasses full of water. A teacup. A coin. A mirror. A pencil. A piece of white paper. A pinch of starch. I promise you a beautiful lesson. Be ready promptly at 7.00 o'clock next Monday evening.

Let me see now. What is the subject for this evening? Oh, yes. *"A Speck of Dust!"* WHEW! It's dusty. Look at the dust on your coat sleeve, shoes, on the rug, shelf, windowsill, on your radio cabinet. Inhale! You just breathed in anywhere from a few hundred to half a million dust particles. What? You don't believe me? All you need to do is to look at a beam of sunlight coming through the window. The bright beam will reveal countless particles of dust. And what is dust? Rub a little off a shelf or table anywhere. Look at it. You see tiny particles of soot, hair, skin, cloth, clay, sand and ash. But where does dust come from? From wear. Every-

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*** Radio Science Lesson given at Big Brother Club hour of WEEI, March 8, 1926.**

thing wears out, in time; by chemical action, friction, and decay, and turns to dust—even as you and I must do. And Dame Nature is a hard task-mistress. She keeps us hustling to buy new shoes and coats for ourselves, new paint and shingles for our houses, new steel girders for our bridges, and cement for worn-out roads. Everything turns to dust—even the rocks of great mountains break up and blow away as dust. Ask your mother if she likes dust. I'll bet she says 'No"—emphatically NO! And I don't blame her, for she probably chases dust, persistent dust, elusive dust, from morning till night.

But, tell me. Does this dust that pesters your mother serve any useful purpose? Yes, it does,—many. And the funny thing about dust is this. We can't seem to live without it or with it. Dust is both a blessing and a curse. I wonder if you ever felt with Wordsworth, the great English poet, the witchery of the soft blue sky? Did the soft blue sky ever melt into your heart? And do you know what makes the sky blue—what gives that wonderful soft blue color? It is dust—countless particles of fine dust. Without dust there would be no blue sky. The heavens would be blacker than we see it on moonless nights. And do you know what changes the dazzling sunbeams into soft restful light of day? Dust again. Yes, sir. Each minute particle catches a glaring beam of sunlight, breaks it up into tiny rays and scatters them in all directions, into every dark nook and corner.

My talk thus far has been about lifeless dust, dead dust. But now we come to the fascinating part of my story, to the invisible word, to the countless millions of living things—living organisms—far too small for the naked eye to see. For dust is alive. It is the home, the residing place of innumerable hordes of living things,—vaster by far than the visible hordes inhabiting the earth. But you want to be convinced. How can I convince you that this is true? Well, you can ask your science teacher to let you look at dust through a powerful microscope—and see this invisible world for yourself—minute living organisms of many sizes and forms. But I know a better plan—I'll tell you how to plant a few dust gardens—and raise them.

For your first dust garden, put a tablespoonful of sirup or sugar into a glass of warm water. Now put in a pinch of

dust. Set the glass in a warm place—quite warm—for two or three days, and look at it occasionally. Action soon starts. The water seems to boil or bubble—foam collects on top—the sugar or sirup disappears, and the liquid acquires a peculiar odor. What produces the change? Let us put a drop of the liquid on a glass slide and examine it through the powerful lens of a compound microscope. See the pretty, glistening, egg-shaped objects—hundreds of them. Those are yeast plants, wild yeast plants. They are always present in air, clinging to particles of dust. And these tiny objects are responsible for all our troubles with intoxication and prohibition. The microscopic yeast plants eat sweet things, such as sugar, and throw off alcohol as a digested waste product. We call the process fermentation. And look again at these funny little plants. See how they grow and multiply. See—the baby yeast plants grow right out from the side of the mother cell and pinch off. And there is no race suicide here. Within a few hours a single yeast cell will produce thousands of little ones. Is the yeast cake you buy of the grocer alive or dead? It should be alive. It consists of millions of cultivated plants —all packed together. You know you can kill a yeast cake— if you boil it or keep it too long. When your mother makes bread, she mixes yeast with the dough, and then she sets it away, where it is warm, for several hours. And what happens? The tiny yeast plants multiply—eat the sugar, digest it—and change the sugar to alcohol. At the same time the minute plants breathe out carbon dioxide. But this gas cannot escape,—it is held in hundreds of little pockets by the sticky dough,—and we say the dough rises. When you bake bread all the alcohol is driven off,—but the pockets of gas remain,—and these are the tiny holes you see in a slice of bread.

And now I want you to plant another dust garden. Take a slice of bread, moisten it—sprinkle a little dust on the top. Lay the slice in a dinner-plate. Cover this with a second plate. Set it away in a warm, dark place for a week or ten days. Isn't this a pretty experiment? After a few days you find a luxuriant growth in your garden. A fuzzy mass, like cobwebs, covers the slice of bread. Look close. See the network of silvery white branches, and the black balls of fruit, hanging from them like apples. Break open one of the black

balls. See, it is filled with thousands of minute seeds, or spores. You have raised a mold garden—and it started from spores clinging to dust particles. There are many kinds of molds: black ones, green ones, yellow ones, pink ones, and red ones. And they do lots of harm—they spoil your mother's bread and cake, they make spots on her bed-linen, they cause the decay of fruits, vegetables and meats,—they even attack living plants and destroy millions of dollars' worth of crops yearly. Molds are not fussy what they eat. They even eat wood, paper, cloth, and leather. And, in spite of all this, molds perform a great service to man,—in fact, we can't get along without them. What do you think happens to all the dead leaves and grass and rubbish? Molds eat this refuse, break it up by digestion, and transform it into rich soils—soluble foods to make plants grow. So you see how molds act as Dame Nature's servants—in helping to make the world cleaner and supplying you and me with good things to eat.

And now let us plant another garden with living dust. With a sterile knife, cut a partly-cooked potato into thick slices. Sprinkle a little dust over the slices, and lay them in a clean plate. Cover with a second plate, set the garden away for three or four days in a warm, dark place, then take the cover off. And what do you see? Funny-looking spots—slimy masses of different shapes, colors and sizes. And what is each spot? It is a growing mass of millions and millions of live, active germs—bacteria—the tiniest of all living things. You could pile more of them on the head of a pin than there are people in the United States. Let's look at some of the spots through a powerful microscope. You see swarms of live organisms: round ones, rod-shaped ones, spiral ones—some are quiet, others spin round and round, or dart rapidly back and forth. And notice how they multiply. The mother simply splits in the middle and make two baby bacteria, and within a single hour the two baby bacteria may grow and become mothers, split in two, and produce four babies. Fast work? Yes, it is. At this rate a single mother bacterium, within the limits of 24 hours may, increase her family to over 16 million offspring. What did you say? Where are bacteria found? Everywhere. There are millions in your mouth and intestines. You find them in large numbers on your skin, in your hair,

under your finger-nails, in water, food, garden soil, and dust. Are bacteria our friends or foes? I'll have to leave this question for my radio science class to answer, for I am afraid Big Brother may stir up a cloud of dust around me unless I stop talking. Good night.

X. WONDERS OF THE NIGHT SKY.*

Good evening, girls and boys. This talk on "Wonders of the Night Skies" is an attempt to co-operate with Big Brother's splendid plan to help make the monotonous and lonesome existence of the brave keepers of our light-ships, lighthouses, and coast-guard stations more endurable. The talk is also for your benefit, for perhaps you feel as Thomas Carlyle did when he complained: "Why did not somebody teach me the constellations, and make me at home in the starry heavens which are always overhead, and which I don't half know to this day." "Contemplated as one grand whole, astronomy is the most beautiful monument of the human mind, the noblest record of its intelligence." Its study cannot fail to arouse the interest and astonishment of the student, to inspire him with feelings of awe and reverence, as he learns of the majestic order and harmony which prevails among the heavenly bodies; and he unconsciously unites in the praise of his Creator.

And let me say to you who grieve, look up into the night skies and find solace—let me say to you who fret and worry, look up into the night skies and find peace—let me say to you who are lonesome, look up into the night skies and find companionship—let me say to you who swell with false pride and conceit, look up into the night skies and see how insignificant you are—let me say to you who pursue the almighty dollar, look up into the night skies and find eternal values—and finally, let me say to you who have lost faith, faith in living, faith in humanity, faith in immortality, faith in God, look up into the night skies:

What though, in solemn silence, all
Move round this dark, terrestrial ball?
What though nor real voice nor sound
Amidst their radiant orbs be found?
In Reason's ear they all rejoice,
And utter forth a glorious voice,
Forever singing as they shine,
"The hand that made us is divine."

* Radio Science Talk at Big Brother Club of WEEI, March 29, 1926.

As an introduction to this study of the stars and constellations, perhaps I ought to mention our own nearest star—the star that gives us light and heat, and makes human life possible on this planet—our own sun. For we belong to a great solar system, with the sun at the center, and circling around it in vast orbits are eight major planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Three of these planets, the ruddy Mars, the giant Jupiter, and the resplendent Venus, are magnificent objects as viewed by the naked eye—but they are not present in the skies tonight. And first of all, tell me this. How does a planet differ from a star? Why, planets are relatively small, near, dark objects, that shine by reflected light, like the moon. Stars are vast suns, flaming balls of incandescent material, at inconceivable distances, that give light and heat. And even to the most casual observer the stars show many interesting characteristics. They seem to follow one another in a grand and majestic procession across the sky. Then too, they seem to rise and set about four minutes earlier each day, so that, we see different constellations with the change of seasons. The night skies of summer and winter look entirely different.

Stars vary in color, depending on their age. Some are bluish, others are white, yellow, orange or red. They also vary in brightness. Some are much brighter than others, due to condition, size or distance. And speaking of distance, do you realize the immensity of stellar measurements? The distances of stars are measured in light years—the distance that light travels in a year. Light travels at the inconceivable speed of 186,000 miles per second, seven times around the earth in a single second. And even with this enormous scale the more distant stars are estimated at distances of thousands of light years. Remember, when you look at a star like Arcturus, you don't see the star, you only see the light that started from that star over 41 years ago. It has taken over 41 years for that light to reach your eyes, traveling at a speed of 186,000 miles per second. Can you imagine that?

Long before the Christian Era, the ancient Egyptians, Arabians, and Chaldeans, mapped out the heavens into star groups—constellations—and gave them names. And tonight I want to show you some of these oldest figures in the picture book of man. Let me be your guide and point out a few

distant suns and interesting groups of stars. Have your pencil and paper ready, and copy directions as I give them to you. And then I want you to follow my directions; to get out of doors any clear evening during the next fortnight; to explore the many wonders of the skies; to feel the thrill of exploration and discovery that seems to divorce your mind from the temporal, the finite, and links you up with the eternal, the infinite.

Are you ready? First get your bearings. Locate the cardinal points of the compass: north, south, east and west. Face northeast. Look high up into the night sky. You see a group of seven stars, four forming a huge bowl and three a curved handle. You can't miss it. That is a famous old constellation, called the Great Bear, or the Big Dipper. And notice, it looks exactly like a mammoth dipper. At seven o'clock tonight it seems to stand on its own handle, with the open bowl facing northwest.

Now locate the two end stars in the bowl of the Big Dipper, the ones farthest away from the handle. These stars are called pointers, because they point at Polaris, the North Star. Just draw an imaginary straight line through the pointers and follow this line to the first star visible to the naked eye—and you come to Polaris, the rather dim North Star—the star that never rises or sets, and towards which the axis of the earth is pointing. And because of the earth's daily rotation on its axis, the Big Dipper and other polar constellations seem to move counterclockwise, in complete circles, around Polaris, once in every twenty-four hours. See if you can make out the interesting star group known as the Little Dipper, with Polaris in the end of the handle.

Let us locate the next constellation. Direct your eyes midway between the two Dippers. Locate the Dragon, a long line of stars curving upward and around the Little Dipper, with four stars at the end that mark the head. It looks just like a real dragon. According to an ancient myth, Draco, the dragon, was the guardian of the golden apples of the Hesperides.

And next let me show you how to find the beautiful constellation Cassiopeia. Copy my directions. Draw a line through the pointers of the Big Dipper to the North Star. Now continue the line for the same distance beyond the North Star, and down toward the horizon you come to a group of stars that form a huge capital M or W in the sky. You behold the

mythical queen Cassiopeia, the queen of Ethiopia, sitting in her royal chair.

Keep that pencil busy. More directions. We have been studying the northern, circum-polar constellations. Now turn around and face south. Find the brightest star in the sky—Sirius, the magnificent Dog Star, beyond all comparison the most brilliant star in the heavens—one of our nearest neighbors, and yet so far away that it requires more than eight years for its light to reach us. And see, the giant Sirius is pure white in color. It is a young sun—-much younger and hotter than our own sun. And look again. For Sirius is in the mouth of a realistic constellation known as the Big Dog, which you can easily make out, sitting on his haunches, and ready to follow his master across the heavens.

And now. I want you to look at the most spectacular group of stars in the sky, the glorious constellation Orion, known in ancient lore as the mighty hunter and the lover of Diana. Copy down these directions. Face the brilliant dog star, Sirius. Now look toward the west. You see three rather faint stars, close together and in the same straight line. The three stars represent the belt or girdle of the mighty giant, Orion. Look directly above the belt to a conspicuous red star. That is Betelgeuse, a mammoth youthful sun that is growing hotter and hotter. Look directly below the belt of three stars. You come to another first-magnitude white star, Rigel, estimated to be 10,000 times larger than our own sun and at the inconceivable distance of 540 light years. Can you imagine that? The rays of light that reach your eyes tonight started from this gigantic sun before Columbus discovered America. A brief inspection will reveal to you the complete outline of the mighty hunter, Orion, with the red star, Betelgeuse, in his right shoulder, Rigel, a white star, in his left foot, and a faint line of stars representing a sword hanging from his girdle.

More directions. Copy them down. Locate Sirius and Betelgeuse again. Now look up, a little higher in the sky, to the eastward. Find a brilliant white star that makes almost a perfect equilateral triangle with Sirius and Betelgeuse—the celestial triangle. This beautiful triangle stands out with remarkable clearness, and the first magnitude white star in the apex is Procyon, in the constellation known as the Little Dog. According to the myth, Orion has two dogs that follow him

through the sky—a Big Dog and a Little Dog. Procyon is a much younger sun than ours and exceedingly hot. It is, moreover, one of our nearest stars, being distant only about ten light years.

To find the next constellation we will start again with Sirius, the brightest star in the sky. Draw a line from Sirius westward, through the belt of Orion, and continue the line in the same direction beyond the belt, and you come to a blood-red, first-magniture star—Aldebaran, in the constellation Taurus, the Bull. Aldebaran is in the eye of the angry Bull, and above you see his long horns, as with lowered head he seems to charge the mighty hunter, Orion. Just beyond the red Aldebaran, a little further to the westward, you see a faint patch of stars—the world-famous Pleiades, or Seven Sisters. The Pleiades were the daughters of Atlas. One of the sisters married a mortal and lost her brightness, so only six stars are now visible to the naked eye.

Start again with Sirius, the dog star. Draw a straight line upward, toward the northwest, through Betelgeuse, the red star in Orion, continue this straight line an equal distance beyond Betelgeuse, and there almost overhead, you come to the glorious twin star, Capella, in the constellation Auriga. Capella is a giant yellow sun, about the same age as our own sun and 200 times larger. It takes 43 years for Capella's light to reach us, and this giant sun is moving away from the earth at a speed of 20 miles per second.

Now I want you to draw an imaginary straight line across the heavens from the bowl of the Big Dipper to Sirius in the South. Half-way between, and almost directly overhead, you find two beautiful conspicuous stars quite close together—Castor and Pollux, in Gemini, the Twins. The ancients believed that Castor and Polux had a favorable influence over navigation—that Neptune, the god of the seas, gave them power over the waves and winds, and for this reason they have been worshipped for centuries as protectors of the sailors.

You have doubtless heard of the famous constellation known as Leo, the Lion, one of the twelve signs of the Zodiac. To locate this group, look almost directly overhead, toward the east from Castor and Pollux, and there you will see a perfect sickle of six stars, with a first magnitude star at the end of the handle. The sickle is in the head of Leo, and the bright star is Regulus, a far-distant sun of vast proportions.

And now we will return to the Dig Dipper. Simply follow the handle of the Dipper down from the bowl—the handle points almost directly at a magnificent orange star, one of the real gems of the night skies,—to Arcturus, in the constellation Boötes, the Bear Driver. Arcturus is a gigantic sun, 500 times bigger than our own sun, and so far away that it takes over 41 years for its light to reach us.

And just a word more before I close. If you sit up until 11 o'clock some evening this week, just take a look over in the northeast, and there, a little above the horizon, you will behold a glorious white star of the first magnitude, Vega. I want you to see this sparkling diamond of the universe, for that is where you and I are going; in that direction faster than a rifle bullet—at a speed of twelve miles a second, over a million miles a day. Yes, sir,—you and I, and our whole solar system. Good night.

Careless Use of Explosives Results in Many Injuries

Approximately 500 children are crippled each year in the United States by playing with blasting caps which they have picked up in the vicinity of mines, quarries, or in the fields where agricultural blasting has been done. This appalling situation is commented on by the Institute of Makers of Explosives in a campaign now being conducted to reduce the casualties from the use of all forms of useful and necessary explosives.

Because of the exceedingly useful place occupied by various explosives in agricultural work, in removing stumps and rock, and digging ditches, the United States Department of Agriculture is anxious that every effort be made in properly educating the users of such dangerous materials to prevent needless injury and loss of life. Too often explosives, blasting caps especially, are left where children may find them. This is inexcusable carelessness.

Injuries are not confined to children, however. Many a man has crippled himself for life by using his teeth to fasten the blasting-cap on the fuze instead of using a crimper, a tool made for the purpose. Some day the biter will lose something besides teeth. In fact, Lingg, one of the Chicago anarchists, committed suicide by biting a blasting cap between his teeth. Accidentally stepping on a cap will often result in a mangled foot. Sparks, flame, heat, blows, friction—all serve to explode the cap to which they are applied.

Explosives are very useful in connection with agricultural work. It is thoroughly safe to use them, if a few simple rules are followed; but carelessness and unintelligent handling often result in terrible injury. It would be very unfortunate if these important agricultural aids were to acquire a bad name as a result of such accidents; and to avoid this outcome, as well as to prevent injury and loss of life, it is extremely important that everyone should be taught to realize the danger that lies in tampering and ignorant handling. Read the directions that come with blasting-caps and other explosives, and heed them.

Bulletin Boards—A Means of Visual Education

Winifred Perry

Theodore Roosevelt Junior High School
San Diego, California

Not all teachers of General Science can have elaborate apparatus for demonstration and experiment. All schools are not provided with Balopticans, and machines for the projection of still films and "movies." But every teacher can to a certain and large degree make up for many deficiencies in equipment by using bulletin boards to illustrate the different units of work.

Not only does the writer use bulletin boards in the classroom, but a large board (35″ x 45″) is in the corridor near the science department which is for the benefit of the 1600 boys and girls of the entire school, as well as for those who are in science classes. The material on this large board varies according to time and local needs. The aim is to change it weekly and the almost constant study of the material—pictures mainly—assures me that the effort is not in vain.

The pupils are encouraged to submit ideas as well as material for this "extension" project. The older boys are always willing to letter the headings for the various subjects.

During the first week in the fall semester under the title of "Mysteries Explored in Science," an interesting picture is shown and appropriately labeled, representing each of the major Sciences, so that new pupils will have an idea of the nature and scope of General Science.

During National Forest Week material pertaining to forest conservation is presented. The week preceding the beginning of the summer vacation the caption is "Enjoy a Safe and Sane Vacation" with a liberal use made of cartoons.

Early in the spring a Cheerful Cherub poem is the thought of the week:

> "We throw our papers on the grass,
> We tear up flowers and act like pests—
> Of all the creatures on the earth
> We're Nature's most ungrateful guests."

Here again cartoons from "Life," "Nature Magazine," etc. help to emphasize the need of good manners out-of-doors.

During the heavy winter rains there is always a great interest in the weather. And to answer the many queries of why, when, and what an exhibit of pictures including barometers, rain gauge, nimbus clouds, weather maps, etc. is shown under another poem from the Cheerful Cherub:

"Ever since the weather began
We've never been a minute without it;
And there's never a moment as well
When someone's not talking about it."

Other popular bulletin boards have appeared under the following headings:

"All nations will use the Metric System"
"Great Scientists; Luther Burbank"
"National Wild Flower Day"; "The Mysteries of Sky-Land";
"A Brush (drawn) in time saves nine"—(the nine teeth are likewise drawn);
"Fakes and Fads" and "Cover up each cough and sneeze
If you don't you'll spread disease."

Children of the Junior High School age, especially, are interested in pictured presentations of their lessons. They often bring in so much material to illustrate their daily work that the smaller boards within the room must be changed several times weekly if every child's contribution is to be displayed. The pictures are culled from magazines, advertisements of all kinds, post-cards and occasionally a kodak picture is appropriate.

These bulletin-boards are work for the teacher, to be sure. But I believe that it is time and effort well spent—even if a set of papers must find their way into the waste basket unmarked. If you haven't the bulletin board hobby—acquire it.

The Use of the Bulletin Board

HENRY R. GOODWIN
Worcester Academy, Worcester, Mass.

THE bulletin board will become, with the expenditure of a little time and thought, one of the teacher's best aids in the teaching of science or, for that matter, in the teaching of any subject. With the bulletin board it is possible to arouse interest in scientific things that otherwise, due to the length of time allotted to the course, could not be touched upon. As well as introducing new material it affords an application of

the old. The clippings that are on the board are founded on the very laws that the pupil is finding so interesting in the class room. It makes the science work actual and reduces any chance of its becoming abstract. Some caution must be used. The bulletin board can very easily defeat its own purpose. If trash and half-baked ideas masquerading as science are allowed to slip from some sensational magazine or lurid newspaper to the bulletin board, it will turn out to be a decided impetus in the wrong direction. A sound, common sense censorship of material is necessary.

Care must be taken in the choice of location for the board. It must attract attention and it cannot accomplish this purpose unless it is in a conspicuous place. It should receive plenty of light. There is a tendency to place the board in some place that cannot be utilized for any other purpose. Obviously this is wrong. Sacrifice black-board room if necessary but have the bulletin board where it must be seen.

The board should have a good appearance. Cork boards may be purchased, but if the price is prohibitive, any soft wood board will do with one provision; it must be large enough. A clipping crowded out over the edge, hanging by a single thumb-tack, and flapping gaily in every breeze not only looks bad but cannot be read. Have the board large enough to receive a fair amount of material. When there is not room for a clipping or picture, wait until it can be fastened on the board properly.

As the purpose of the board is to bring new ideas to the class and supplement the old, it must have the support of the pupils. They must be encouraged to bring in interesting clippings and must feel free to place these clippings on the board. This search for new articles should stimulate the reading of modern scientific magazines. The consistent reading of such periodicals would prove in itself a good course in general science. It should not be hard to start the class contributing to the support of the board. The collecting instinct is natural. We see it all about us, in addition to this there is a certain thrill and feeling of superiority that comes with the giving of knowledge to a contemporary which is very soothing to the young ego.

The teacher's actual work on the board should be restricted as largely as possible to supervision. A committee may be

appointed to keep the board in an artistic manner and take that duty from the hands of the teacher. When some very good article is brought in, the teacher may call attention to it verbally, or the committee may make topic headlines from cardboard with black inch letters. These headlines readily attract attention. The material must be kept constantly moving. None of us will spend much time watching something that never moves. If interest begins to slacken and the board starts to stagnate, the teacher might announce the title of some article he had read and ask someone to bring it in.

The teacher may also use the board in order to secure better written work from the class. Especially good papers may be posted on the board and used as models by the rest of the class. This also serves to show the student what his classmates are doing. The teacher may draw attention to the board in another manner which, although it borders on coercion, often proves effective. At irregular intervals short quizzes may be given on subjects that have been posted on the board. This method forces the attention of some pupils who are difficult to reach in any other manner. It should, however, be used sparingly if at all. The bulletin can be a great aid to the teacher but only if the pupils are interested in it for its own intrinsic value. Their interest can be led but not driven. True learning can come only with interest.

"Scientific Explanations"

A Short Play on the Study of Sound

AMY L. COATS
Barbour Intermediate School, Detroit, Mich.

Characters: Frank and Clarene (brother and sister); a crowd of boys and girls (members of the same class in Science).

Time: One evening after school during the second semester of 1927.

Place: Act 1—Living room in Frank and Clarene's home.
Act 2—Home of Clifford, one of their friends.

ACT 1

(*Enter Frank, blowing a sharp, shrill whistle. Clarene is seated in front of her easel sketching.*)

Clarene. (*Looking up from her work*) Oh! Frank, do stop blowing that whistle. It hurts my ears!

Frank. Hurts your ears?

Clarene. Yes, Frank, it really hurts. I wish you'd give that whistle to me.

Frank. All right, Clarene, I'll give it to you, if you can give a scientific explanation telling me just why it hurts your ears.

Clarene. Maybe you think I can't. You're always wanting scientific explanations for everything. I want you to know, Frank, that you are not the only person in our family who is studying science.

Frank. All right. I'm waiting for your explanation.

Clarene. (*Turning her easel around, exhibiting a chart showing the construction of the human ear.*) I'm just finishing this sketch of the ear for our Science Class exhibit on the study of sound. Each of us is to contribute something, you know. There are three parts to the human ear (*pointing them out on the sketch*),—the outer, middle, and the inner ear. The outer ear leads to the ear drum, a thin membrane, which receives the sound waves. When sound waves strike the ear drum they cause the three small bones in the middle ear to vibrate. These vibrations are transmitted to the inner ear, which is the real organ of hearing. Now, Frank, when you blew on that sharp whistle, you produced more than 4100 vibrations per second. The human ear cannot receive more than 4100 vibrations per second without pain.

Frank. The whistle is yours, Clarene. You have really surprised me.

Clarene. Well, the girls in our class have made up our minds that science is going to mean just as much to us as it means to you boys.

(*Telephone rings. Frank answers the telephone, while Clarene is putting a few finishing touches on her sketch.*)

Frank. Hello! Yes, this is Frank. . . . Oh, yes, thank you, we'll be glad to come. . . . All right, we'll be right over. . . . (*Turning to Clarene.*) It's Clifford. He wants us to come over. He said the whole crowd stopped at his house after school. They're playing games and doing experiments on sound. They want me to show that experiment with glasses of water.

Clarene. Oh! let's hurry and get ready.

Curtain

Act 2

(*At Clifford's home, crowd of boys and girls gathered around a table on which are eight glass tubes with water at different depths.*)

Frank. Now, listen, and I'll play the scale. (*Blows on each of the eight glasses in succession.*)

William. Why, Frank, you're a regular magician!

Howard. Magician! To hear you talk, William, a person might think that you had lived back in the Middle Ages, when people were superstitious and believed in witches and ghosts. There's no magic about this. I can give a scientific explanation for this experiment. When you blow on the glass you cause the air particles inside the glass to vibrate up and down. Now, the pitch of a note depends upon the number of vibrations per second, and the number of vibrations per second depends upon the length of the air column. If the air column is short, there are more vibrations per second. So, the shorter the air column, the higher the pitch. We can change the pitch by changing the amount of water in the glass.

William B. I call that a scientific explanation all right. It reminds me of something I read today about musical instruments. In a cornet you change the length of the air column by moving pistons up and down.

Myrtle M. In the trombone, you change the length of the air column by sliding a portion of the tube in and out this way (*motions*). It is also possible to change the notes by blowing harder and so get overtones.

June T. Overtones! I wish somebody would tell me just what is meant by overtones. I don't understand just what that means.

Lillian T. I can tell you, June. Every musical tone has three characteristics,—pitch, loudness and quality. By quality we mean the richness or sweetness of a tone, and quality depends upon the number and the nature of the overtones. Perhaps you have noticed on a pond or lake the small water waves or ripples riding on the larger waves. I always compare overtones with these little waves riding upon the big waves. The tones produced by a string vibrating in segments or in parts are called overtones.

Clifford. Here's a drawing I made of overtones for our exhibit. This is the fundamental (*pointing them out*), this the first overtone, and this is the second overtone.

Eugene. You said something about loudness and pitch of a tone, Lillian.

Gordon. I can tell you what pitch means. When we speak of a musical note as high or low we refer to its pitch. The pitch depends upon the number of vibrations per second. The human ear cannot hear less than 16 vibrations per second nor more than 40,000 vibrations per second.

Frank. If there are more than 4100 vibrations per second, it hurts, doesn't it, Clarene?

Clarene. Yes, but I still have the whistle (*holds it up*).

William LeD. You said something about loudness too, Lillian.

Frank H. Oh, I can tell what is meant by loudness of a musical tone. If you strike a piano key very hard the tone is louder because the piano wire vibrates up and down through a greater distance, or, to be more scientific, we should say that loudness depends upon the amplitude of vibration.

Marian R. The book I read today in science class showed a picture of the musical scale, so I made this sketch of it for our exhibit. When you strike middle C on the piano, you produce 256 vibrations per second. When you strike "C" an octave higher we hear twice as many or 512 vibrations per second.

Carl. What is your report about, Harold?

Harold. Oh, I'm going to give a report about acoustics.

Byron. Acoustics! What do you mean by acoustics? How do you spell it?

Harold. A-c-o-u-s-t-i-c-s. We speak of an auditorium as having good acoustic properties when everybody in the audience can hear distinctly. The architect who planned our school building had to keep in mind the laws of acoustic properties, otherwise we should not be able to hear well in our auditorium. We would hear echoes if our auditorium were not constructed properly.

Raymond. Echoes! I've taken echoes for my subject.

Jack. Tell us about echoes, Raymond.

Raymond. An echo is a reflected sound wave. An echo is produced when sound waves strike a solid wall or a cliff, and rebound to our ears, causing us to hear the sound again. Continuous, rolling thunder is a result of multiple echoes.

Jessie. I made up a problem about thunder and lightning.

Eleanora. What is your problem, Jessie?

Jessie. (Reads from paper.) How far away is a storm if you hear the thunder 5 seconds after you see the lightning?

Alfred. I'd like to know how you'd solve that kind of problem.

Jessie. Well, sound travels about 1130 feet per second, so in 5 seconds it would travel 5 times 1130 or 5650 feet. There are 5280 feet in a mile. So, the storm is a little over a mile away.

Milton. You didn't say anything about how long it took the light from the lightning to travel to your eye, Jessie.

Frank G. Well, we all know, Milton, that light travels 186,000 miles per second which is about a million times as fast as the speed of sound, so we need not consider the time it takes the light to travel.

Celeste. (*Looking at her wrist watch.*) Oh! it's almost five o'clock. I must go.

Jennie. Before we go I'd like to have some one answer one more question.

Irene. What is your question, Jennie?

Jennie. What is the difference between music and noise? I want a scientific explanation.

Mary. Oh, I can tell you. When vibrations which are received by the ear follow each other at regular intervals, the sound is musical. If the vibrations come irregularly, we call the sound a noise.

John W. Some of us can demonstrate what is meant by noise. (*Blow whistles and horns in discordant manner for about 5 seconds.*)

Clifford. We've had a good demonstration of noise. I think Carl and Frank ought to give us a demonstration of music on their violins before you go home.

Frank G. All right, we'll play, won't we Carl, if Marian will accompany us on the piano.

(*Marian, Frank G. and Carl play ....*)

Curtain

The Cabin of Sound

Arthur W. Wathen
New Bedford High School, Massachusetts

Scene: Summer cabin of noted singer on shores of lake in the mountains.

Signor Caprini is seated in the living room of his small summer cottage where he likes to spend part of his vacation alone roughing it with some neighbor friends. Time: evening.

His neighbor and friend, Henry Blake, enters after a light knock.

H. B. Fine evening, Signor Caprini.

S. C. Good evening, Henry. Glad to see you.

H. B. Had a great swim this afternoon over to the cliff across this side of the lake and back.

S. C. Ah, ha! Let's see about how far you swam.

(*Goes to door and shouts, "Hello." Counts the seconds up to five. A faint hello is distinctly heard, given by someone backstage.*)

S. C. Well, you swam a little over a mile.

H. B. How so, Signor. I recall something about the speed of sound waves—but it is a bit hazy now.

S. C. Well, sound travels through air at a speed of 1100 feet per second . It took five seconds for the sound waves from my voice to travel to the cliff and back. Hence, 5500 feet is the distance over and back or about 2750 feet to the cliff.

H. B. By the way, Signor, hope our old trapper friend does not drop in to expatiate this evening.

S. C. Yes, he pinned me down two hours the other evening on the same bear story. Guess I can fix him if he does come.

(*A knock at the door. Old Vermont trapper with a backwoodsman twang enters at Signor Caprini's, "Come in."*)

O. T. Wall, good ev'nin', gents. I was daown repairing my canoe and thought I would step in fer a spell. Went fishin' up t'other end of the lake this afternoon and caught some real splendid salmon traout.

S. C. Is that so, Zeke. You'll have to give us a tip on the best places before long.

O. T. Glad to, Seegneer. Wish you could have been with me on that bear hunt.

S. C. Excuse me for a moment, gentlemen.

(Goes back of screen to kitchen, humming as he goes. Zeke starts to relate bear story.)

O. T. You know it was up on Old Mountain, and we had just started up a deep gully when with a crash and a roar, a huge grizzly came tearing daown through the underbrush.

(Before Zeke finishes his sentence, beautiful strains of music are heard backstage and sidestage. Have different pupils play different musical instruments, a snatch of harmony from a male quartette, major chord sounded with tuning forks, part of a beautiful aria on a phonograph. Zeke listens charmed apparently.)

H. B. Is it not strange about these beautiful strains of music that are heard around this lake, Zeke?

O. T. I swan, it's the greatest puzzlement to me. They say it is haunted by the sperit of music.

(At this time Signor Caprini has prepared an oscillograph using an arc lamp or bright source of light, all in back of screen. This is a little carton like a small cylinder with hole at side and end and rubber diaphragm on end. Can be easily made or procured from supply house. The room should be somewhat darkened. He sings into this, prolonging the vowels; and graphs of light are seen on the wall or ceiling, varying strangely with the different words or vowels.)

H. B. Look, Zeke, on the wall. Signor Caprini is so high-powered in his singing that darts of light sometimes come from his voice. See as he sings the different vowels the flame changes shape! They tell me he can fairly sear one with a livid ray from his voice.

O. T. You don't say, Cap'n. Hickory! *(Jumps up.)* Guess I'll be going. Got a little more work daown to the lake. *(Exits in considerable alarm.)*

S. C. *(Returning.)* Well, that worked finely. *(Explains and shows the oscillograph and how it works.)*

S. C. You know there are many simple laws and principles of music and sound that are easily demonstrated. For instance, sympathetic vibrations are set up most anywhere when something has the same natural period of vibration as the

sound that is being emitted. (*He shows this with two tuning forks mounted. Then he strikes C on the piano, touching the vibrating strings and the harmonies are heard. Some article in the room can be made to vibrate, or a cornet can be sounded and cause a suspended pan containing shot or gravel to rattle in sympathy.*)

S. C. Singers are sometimes bothered by sympathetic vibrations. When they start to sing they find some contour of the room or nearby objects are in exact tune. Often by moving about a bit this can be overcome. I have even heard it said that Caruso was in fear that he might sometime sing a powerful note in such surroundings that the vibrations exactly in tune with his natural period of vibration would shatter his singing organism. Here is a bit of an odd stunt in sound.

(*He takes two glass tubes, one of which exactly fits over the other, placing the lower one over a candle flame, and adjusting the other up and down until the flame causes a loud shriek to be emitted. Other experiments can be substituted or added, if desired.*)

S. C. By the way, Henry, perhaps you would not believe that I have developed a ventriloquism trick, somewhat different, in that I can change the quality of my voice entirely so that it sounds like another person's voice. I'll sing this pretty song and try to throw it, say just out of the cabin.

(*Choose a fine bass or tenor song and have some good singer back stage. Signor C. sits at piano with back to audience or sideways and articulates and breathes, forming the words exactly in unison with the singer. He, of course, plays the song.*)

H. B. (*At conclusion of song.*) Well, you have dumbfounded me. Things will be getting spooky if I stay much longer. Have enjoyed your entertainment first rate. Tomorrow you know we have that long tramp over the mountain, so we must retire in good season. Now, be a good fellow and do not throw your voice through me in darts of fire. Good night, Signor. (*Exits in mock haste as though dodging something.*)

S. C. Good night, Henry.

Irene Helps Find Radium*

By Clifford Hendricks,
University of Nebraska, Lincoln, Nebraska.

Irene's grandfather Curie was dead. In all the twelve years of her life he had been her almost constant companion. During her waking hours he was her playmate and her teacher.

No, Irene was not an orphan. Her father was Doctor Pierre Curie, a very famous French scientist, and her mother is equally, if not better known than her father. She finished the work which earned her a doctor of philosophy degree when Irene was only two years old. Is it any wonder then that Irene was, in her very babyhood, much in Grandpa Curie's charge?

But I would have you understand that Irene, without knowing it, helped to find that wonderful metal called radium. For you see, by being Grandfather's girl, she permitted Mother to go right on with her work in the laboratory. This work finally resulted in finding not only radium but another element called polonium as well.

Have you ever watched the shining figures upon your radio watch or clock dial at night, and wondered what made the glow? The paint in each letter has, mixed in with it, a mere trace of what is called radium chloride. This radium in this compound constantly gives off what are called *rays,*—very, very minute electrically-charged particles, travelling at terrific speed, nearly as fast as light travels. These striking on other substances in the paint are suddenly stopped, thus causing these substances to emit visible light.

No, they will not cease to produce the light as long as the paint lasts. It seems quite wonderful, doesn't it? Irene's mother says it really would "give out" after many, many years, but not during your lifetime. There are a number of other substances that give off these rays, but none that at all compare with radium.

And it was Irene's mother who first found radium. It came about in this way. A scientist one day placed some material, which you would call a powder or rock, over some

* Published in Cornell Rural School Leaflets, Vol. 20, No. 1, p. 37.

photographic plates which had not yet been used. We today use photo films instead of plates, but this was in the days before films were known. Some time later he found these plates had been affected as if exposed to light. He put the powder, called uranium compound, away in a very dark room and left it for several months, and tried it over the plates again. The result was the same. Why should this material make a picture upon the plate in the dark, even through its covering of black paper? This was the problem that Madame Curie, as Irene's mother was called in French, set for herself to solve. And so while baby Irene kicked up her chubby heels and gurgled in her cradle, with grandfather close by, Mother Curie began her thirteen-year task which finally resulted in the preparation of a very small speck of the white, pure metal radium.

How did she do it? She first did some experiments which measured these rays coming from the uranium compounds. In her own words she says: "I undertook next to discover if there were other elements possessing the same property, and with this aim I examined all the elements known. . . . I examined also a great number of minerals . . . certain ones seemed abnormal . . . (had a) much greater (radiation) than the amount I (expected). This greatly surprised us." She says "us," because Irene's father was helping her mother in these experiments by the time she had worked this far.

Since this mineral, or "ore" it might be called—you'd probably call it a piece of rock—produced so much greater an effect upon the photographer's plate than any other substance they had examined, Irene's mother decided there must be a new, never-before-known element in it which made the difference. She says: "I had a passionate desire to (find out if this were true) as rapidly as possible."

Irene's father now gave up all his own experiments and joined her mother in an effort to find this new substance. They decided to try to find it in a mineral called pitchblende. What they did was to separate this ore into different substances and test each for its rays. They discarded the parts that did not show the rays. In this way they soon found two instead of one new ray-forming substance. One of them Irene's mother called polonium, for Irene's other grandfather had lived all his life in a country called Poland; and the other, because it showed so many rays, she called radium.

Now, while Madame Curie and her husband felt very sure they had two new elements, as the chemists call them, the scientists were not quite ready to accept them. You see they had found them by simply measuring their rays. The chemists required that they prove their existence in other ways.

There was so little polonium and radium in the pitchblende that they had to secure several tons of it from some mines in Bohemia and slowly and patiently separate the parts containing the polonium and radium from the other material. She said that she often had to lift as much as forty or fifty pounds —as heavy as a medium-sized sack of flour—of the material from one container to another, and often she would have to stir as much as a wash-boiler full of stuff with an iron bar for hours at a time. They did this work in an old shed that allowed the rain to leak in, heated in winter by only one old sooty stove, and whose glass roof made it almost a bake-oven in summer. In spite of these difficulties, after five years of work, she prepared some pure radium chloride, perhaps a little mass of powder about the size of a pin-head. By studying this, she showed to the satisfaction of all scientists that radium was really and truly a new element never before known by anybody.

Can you picture what Madame Curie did? When Irene was about one year old, her mother started with a big wagon-load of what you would call dirt. By working almost continuously, by the time Irene was old enough to go to school, her mother had worked over and thrown away almost all of it, until she had this mere speck of stuff which gave off a soft, glowing light at night. It seems a great deal of trouble for such a little material, doesn't it? But scientists the world over did not think it a small matter. Twice was her mother given what is called the Nobel prize for her patient and careful work upon radium. Everywhere learned scientists were anxious to hear Irene's father and mother tell about their work and discoveries.

Some twenty years later, Irene and her sister, Eve, who is seven years younger than she, were invited to come with their mother to America. They traveled with her over much of the United States and saw, among other things, the wonderful Grand Canyon and the great river of water plunging

over Niagara Falls; they heard the President of the United States make a fine speech about their mother; they saw him give her $100,000 worth of radium chloride to take back to France to use in her laboratory. Certainly Irene must have been happy when she saw how much people honored her mother for the work she had done, and no doubt, if she thought of it, she did not regret that she had stayed at home with her grandpa so that her mother could go on with her experiments.

Radium Gift a Help in Research

Science Service gives us a brief account of what has already been accomplished with the radium which Madame Curie took back to France with her in 1921. Madame Lattis, a worker in Mme. Curie's laboratory, was interested in finding the best method of wrapping up the applicator tubes which are brought in contact with the flesh of a patient who receives radium treatment. Her results lead her into fundamental studies of the absorption of radium rays by different materials. She was able to confirm definitely, using the American radium, a law discovered last year by Georges Fournier, in the same laboratory, according to which there is a simple mathematical relation between the absorption coefficient of a material and its atomic number. She also attained her original object for she learned how to avoid the destruction of flesh, or necrosis, which occurs when a radium tube is improperly used. Essentially her method is to use first a thin sheet of a dense metal, such as platinum, around the radium, and then to wrap the tube in many layers of light material, such as gauze, to absorb the secondary rays issuing from the platinum. This method, which has also been developed empirically, is now for the first time correctly understood and explained.

In her latest report published in the Annals of the University of Paris, Mme. Curie tells of the great and growing activity of the group which she directs. No less than thirty investigators are studying different problems of radio-activity, and fifteen scientific papers were published from the laboratory between November 1925 and May 1926. In addition, the various technical services of the laboratory have been kept up. Madame Curie's daughter, Dr. Irene Curie, who accompanied her mother on her visit to this country, is one of the most productive research workers at the radium institute, and also has charge of some of the laboratory teaching.

The New Books

Heart and Athletics—Deutsch and Kauf—Translated by Louis M. Warfield—187 pages—19 drawings—$2.50—C. V. Mosby Company, St. Louis.

In this volume we find authoritative opinions upon the influence of athletics upon the heart. Clinical researches in which thousands of men and women athletes were examined, formed the basis of the conclusions drawn. It is interesting to learn that rowing, bicycling and skiing lead to greater changes in the heart than does football.

Hygiene and Sanitation—Jessie Feiring Williams—344 pages—illustrated—$2.00 net—W. B. Saunders Company, Philadelphia.

Modern health care is the core of this new book, written for beginners. It considers the effort of the individual to live a wholesome life; and the united efforts of individuals in a community to control the environment and human factors involved in fighting disease and conserving health. The book covers: care of oneself; expectant mothers; babies and children; the aged and invalid. There are chapters on health care in the home, in the factory, in the city and nation. Each chapter is followed by a set of questions and practical exercises.

The New Physical Education—Thomas D. Wood and Rosalind F. Cassidy—457 pages—The Macmillan Company.

"The New Physical Education" is a printed text on the natural progress of physical education, which has developed at Teachers College, Columbia University. It is still in a state of growth, and yet has now had 15 years of research in the formulation, application, and testing of theories and practice.

On Being a Girl—Jessie E. Gibson—326 pages—The Macmillan Company.

This book is the outgrowth of discussion groups for young high school girls, and takes up the girl's problems in a way that is suggestive and helpful to teachers who are interested in the welfare of girls in their teens. The book treats the girl's community, her family and friends, and her personal problems.

The Unity of Life—H. R. Royston—281 pages—16 full page illustrations and 23 diagrams—The World Book Company.

One aim of this book is to answer the "How" and "Why" of nature study matter which the children ask. It further helps to teach the main facts of the reproduction of life. The chapter headings are: Life; Simple Forms of Life; A Type Plant; A Type Animal; Seeds and Eggs; Marriage among Plants; Marriage among Animals; Some Different Kinds of Flowering Plants; Different Kinds of Animals; The Origin of Life; Metamorphosis and Alternation; Sponging and Co-operation; Carniverous Plants; Darwinism; Some Primitive Animals and Plants.

Biology—W. H. Atwood—522 pages—338 illustrations—$1.68—P. Blakiston's Son and Company.

This is one of the texts in the Secondary School Science Series, edited by Professors R. S. Powers. In this book each activity, as respiration for example, is studied for plants, animals and man grouped into one unit, rather than treating it separately in three different units. Because the great principles of life operate in a uniform manner in the activities of plants, animals and man, the author believes the method he employs is a more effective way of teaching biology. There are helpful summaries, review questions, and suggested student activities.

A New Experimental Science, Part II.—J. G. Frewin—111 pages—52 illustrations—50 cents—Oxford University Press, American Branch.

This takes up (1) the chemistry and (2) the physics of water, including hydrogen, buoyancy, hydrometers, calorimetry, siphon, latent heat, and hygrometry. A third section treats of magnets and the compass. Descriptions are clear and the experiments are simple. It is a very interesting and suggestive book.

Supplementary Geography—James F. Chamberlain and Arthur H. Chamberlain—1. North America—350 pages—111 illustrations—2. Europe—264 pages—100 illustrations—The Macmillan Company.

These two books are revisions in the series on the continents and their peoples. The World War and our great industrial growth have altered the world to such an extent that a complete rewriting of these books has been undertaken. The new maps and illustrations bring the books up to date and make them very attractive.

Radio Encyclopedia—S. Gernsback—168 pages—illustrated—published by Sidney Gernsback, N. Y. C.

This is a very complete treatment of all the terms used in radio, with clear diagrams to explain them. The terms are alphabetically arranged. Men who have become prominent because of work relating to radio are given notice.

The Elements of Radio-Communication—O. F. Brown—216 pages—146 diagrams—$3.50—Oxford University Press, N. Y. C.

This book gives the radio student and the radio-set owner the fundamental principles underlying radio transmission and reception. The mechanical treatment has been reduced to a minimum. Teachers interestel in radio will find this book of value.

General Physics—4th edition—Henry Crew—674 pages—The Macmillan Company.

In this review, the author has taken "advantage of the increased unity of views which is made possible by recent discoveries in physics." The book is a little larger than the old edition, but the fundamental principles stand as of old, only they are refined and modified in accord with our new knowledge.

Columbia Research Bureau Physics Tests—H. W. Farwell and B. D. Wood—World Book Company

These tests, "Forms A and B," cover the widely used physics material covering the college entrance requirements. They are of the true-false type. There are 144 statements in each test.

Columbia Research Bureau Algebra Tests—A. S. Otis and B. D. Wood—2 forms, A and B—specimen sets 20 cents—World Book Company.

These tests are designed to provide high schools and colleges with a reliable and comparable measure of students' ability and achievement.

1927 *Year Book*—59 pages—Research Service Company—Los Angeles.

A report of papers given at annual conferences on education, research and guidance. It includes material on influence of education on intelligence, typical reading errors, corrective teaching in arithmetic, psychological clinic, reforms in examinations, value of true-false tests, pupil-teacher participations, curriculum research, and the menace of brains.

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Our Trans-Atlantic Flight; R. E. Byrd. Nat. Geog. Mag., 52:346-368, Sept. 1927.
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Learning How to Use Our Wings. Sci. Am., p. 167, Aug. 1927.
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How Lindberg Navigated the Atlantic: The Inductor Compass. Sci. and Inv., 15:296, Aug. 1927..
Langley's Aerodrome. Sci. Mo., 25:92, July, 1927.
Lindberg's Partner. Lit. Dig., 94:4:18, July 23, 1927.
Lindberg's Leap to Paris and Fame. Lit. Dig., 93:10:5, June 4, 1927.
A Vision of Aviation's Future. Pop. Sci. Mo., 111:32, July 1927.
Eight Miles—Straight Up. Pop. Mech., 48:177, Aug. 1927.
The Rocket Ship of the Future. Lit. Dig., 93:13:20, June 25, 1927.

AIR PORTS

Recent Developments of Principal Air Ports in the West. Am. City, 37:1, July 1927.

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The History of the Alphabet. Sci. Mo., 25:97-118, July 1927.

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Mars—The Mystery Planet. Sci. & Inv., 15:124, June 1927.
What Star Gazers are Doing for Us." Pop. Mech., 48:26, July, 1927.

ATOMS

The Reality of the Atom. Jo. Chem. Ed., 4:327, March 1927.

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When Canaries go to School. Pop. Mech., 48:258, Aug. 1927.

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A New Era of Huge Bridges. Pop. Sci. Mo., 111:24, July 1927.
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The Relation of Chemistry to Health and Disease. Jo. Chem. Ed., 4:711, June 1927.
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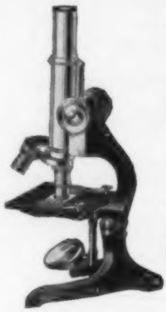

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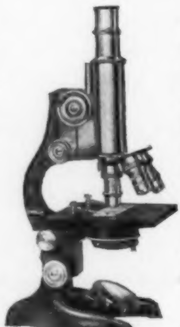

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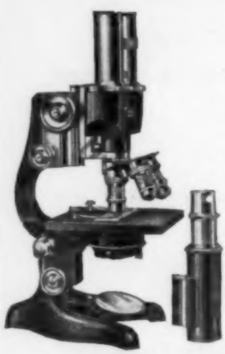

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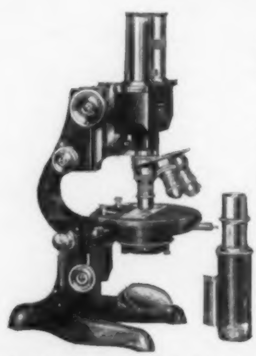

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American City. 443 Fourth Ave., New York City. Monthly. $4.00 a year, 50c a copy. The science problems of city and rural communities are treated in numerous articles, well illustrated. A valuable student and teacher reference.

The American Food Journal. 468 Fourth Avenue, New York City. Monthly. $3.00 a year, 25c a copy. Articles on food manufacture, food legislation, and experiments in nutrition.

Commercial America. Philadelphia Commercial Museum, Philadelphia, Pa. $2.00 a year. Ill. Commercial production. New inventions. Will interest commercial geography and science teachers.

The Educational Screen. 5 South Wabash Avenue, Chicago. Monthly. 20c a copy, $1.50 a year; with "1000 and One Films," $1.75 a year. Discusses the use of motion pictures, slides, and other visual aids in our schools; gives brief descriptions of educational films, and lists of theatrical films which are suitable for children. The journal is entirely educational, having no commercial affiliations.

The Home Economist. 468 Fourth Ave., New York City. Monthly. 10c a copy, $1 a year. Gives practical discussions of everyday classroom problems, lesson outlines and plans.

Garden and Home Builder. Garden City, N. Y. Monthly. 35c a copy, $3.00 a year. Ill. Helpful to amateur gardeners, home makers, teachers and pupils.

General Science Quarterly. Salem, Mass. Quarterly. 40c a copy, $1.50 a year. The only journal published devoted alone to science in the elementary and secondary schools. It tells what schools are doing in science, gives lesson plans, demonstrations, and an extensive bibliography of usable articles in current periodicals.

The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Hygeia. 535 North Dearborn St., Chicago. Monthly. 25c a copy, $3.00 a year. Popular articles on individual and community health. A valuable supplement to classroom work in hygiene.

Industrial and Engineering Chemistry. Box 505, Washington, D. C. Monthly. 75c a copy, $7.50 a year. A technical journal which contains much material which teachers can use.

Journal of Chemical Education. Kodak Park, Rochester, N. Y. Monthly. $2.00 a year. Promotes chemical education; primarily a journal for the chemistry teacher. Digests of activities of chemical associations.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 617 Mills Bldg., 700 17th Street N. W., Washington, D. C. Monthly. 25c a copy, $2.50 a year. For teachers.

The Literary Digest. 354 Fourth Ave., New York. Weekly. 10c a copy, $4.00 a year. Has a department, "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

National Geographic Magazine. Washington, D. C. Monthly. 50c a copy, $3.50 a year. Best monthly journal for high-grade pictures. Articles are of interest to general readers, pupils and teachers, as well as to geographers.

The Nation's Health. 22 East Ontario Street, Chicago, Ill. Monthly. $3.00 a year, 25c a copy. An illustrated magazine devoted to community, industrial and institutional health problems. Very helpful to the science and hygiene teacher.

Photo-Era Magazine. Wolfeboro, New Hampshire. Monthly. 25c a copy, $2.50 a year. This magazine is for the beginner, the advanced amateur, and the professional photographer. It has much for the science department of universities, schools and summer camps, and will help instructors and pupils to make better photographs.

The Playground. 315 Fowler Avenue, New York City. Monthly. $2 a year, 25c a copy. Illustrated, devoted to outdoor recreation, for home, school and community.

Popular Mechanics Magazine. Chicago. Monthly. 25c a copy, $3.00 a year. Short science items and articles, well illustrated. Appeals strongly to elementary pupils. Suggests many construction problems.

Popular Science Monthly. 225 West 39th Street, New York City. Monthly. $2.50 a year, 25c a copy. A review in text and pictures of the news of science and invention, presented in a humanistic and inspirational way. Used as a supplement to text-books in many high schools. Valuable to science pupils and teachers.

Radio News. 53 Park Place, New York City. 25c a copy, $2.50 per year. Monthly. A practical periodical for all who are interested in radio. Gives radio progress, new hook-ups, and gives much help to one who may wish to construct his own set.

Safety Engineering. 119 Nassau St., New York. Monthly. $3.00 a year, 25c a copy. A journal devoted to conservation of life and property, and contains much material helpful in science classes.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Science Classroom. Issued by "Popular Science Monthly," October to June. 25c a year. A valuable teacher's aid, giving lesson plans, experiments, and many reference suggestions for secondary science teachers.

Scientific American. Woolworth Building, New York. Monthly. 35c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated. Particularly valuable to high school science pupils and teachers.

Science and Invention. 53 Park Place, New York City. Monthly. 25c per copy, $2.50 a year. Ill. Popular articles on astronomy, physics, photography, radio-activity, medicine, and, in fact, science in general.

Scientific Monthly. Garrison, N. Y. 50c a copy, $5.00 a year. Articles, as a rule, are more along lines of pure science. Much of value to teachers. Articles can be read to advantage by many pupils.

Science News-Letter. Science Service, 1115 Connecticut Ave., Washington, D. C. Weekly. 10c a copy, $5.00 a year. Gives a valuable current summary of the progress of science, in a form usable in science classes.

Transactions of the Illuminating Engineering Society. 29 West 39th Street, New York. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.